Efficacy and Evaluation of Various Technologies to Clean and Remove Biologicals from Spacecraft Materials†

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For future robotic missions to other bodies in the solar system, there is a need to prepare and maintain equipment and materials that are as free from bacteria and biological materials as possible. Surfaces of critical parts should be as clean as possible, so as to avoid confusion by future detection methods. Towards that end, microbes of various kinds were artificially coated onto coupons made of aluminum that is commonly used in building spacecraft. Cleaning protocols used in this study involves standard swabbing techniques, mechanical dislodging procedures, etc. Additional tests such as use of various kinds of solvents, enzymes, and plasma cleaning were performed. Some established and commercially available cleaning systems were tested. Changes elucidated by various cleaning procedures on the microbial population and molecule distribution were monitored by conventional spread plate technique, epifluorescent microscopy, PCR DGGE and lipid analysis. Total organic carbon analysis, Confocal, and Environmental Scanning Electron Microscopy were also employed to determine surface cleanliness. Electron and epifluorescent microscopic examinations revealed that microbial cells underwent considerable morphological and physiological changes due to desiccation, detergent concentration, plasma, and enzyme treatments. Preliminary results conclude that when dried on surfaces, microbes can no longer be removed by simple rinsing with water or solvents. A small survey of organic solvents including ethanol, acetone, ethyl acetate, methylethyl ketone, dichloromethane and detergents including Triton X-114, Tween-80 and some commercial preparations were evaluated for their efficacy at removing spores. Studies comparing the efficacy of Triton X-114, water, ethanol and various enzymes demonstrated that enzyme treatment released more intact spores than any other solvents and detergents employed. Wiping with solvents left the artificial biofilm largely intact. Although aqueous abrasion removed more cells, it caused a significant fraction to lyse, spreading cell debris over the surface. Commercially established systems seem to be effective in removing both whole cells and biomolecules. However, the material compatibility of various spacecraft parts should be carefully considered when employing solvent-based and/or higher temperature-dependent commercial cleaning systems.

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